



Armed Forces College of Medicine (AFCM)

Histology Department



Red Blood Cells

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Intended Learning Objectives (ILO)



**By the end of this lecture the student should
be able to:**

- **Correlate** the structure of RBCs to its function.
- **Interpret** the defective structure of the RBC in different diseases.

Lecture Plan



- 1. Part 1 (3 min): Introduction to blood elements**
- 2. Part 2 (40 min): RBCs structure and function**
- 3. Part 3 (3 min): Summary**
- 4. Lecture Quiz (4 min)**

Blood



- = A special type of connective tissue in which the matrix is fluid (plasma).
- Average volume in adult : 5 liters

Components of blood

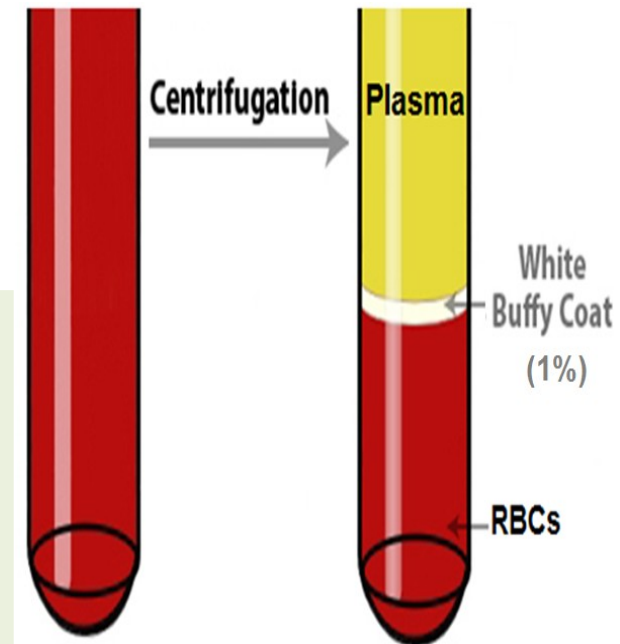
Plasma

- 1- **Water** (92% of plasma)
- 2- **Proteins**
- 3- **Others:**
(Electrolytes, Nutrients, Respiratory gases, Waste)

Blood elements 45%

- 1- **Red blood corpuscles (RBCs) = Erythrocytes**
- 2- **White blood cells (WBCs) = Leucocytes**

Immunology and Blood Module



Red Blood Corpuscles (Erythrocytes)



Origin: Stem cells in red bone marrow

Number

Shape:

Size

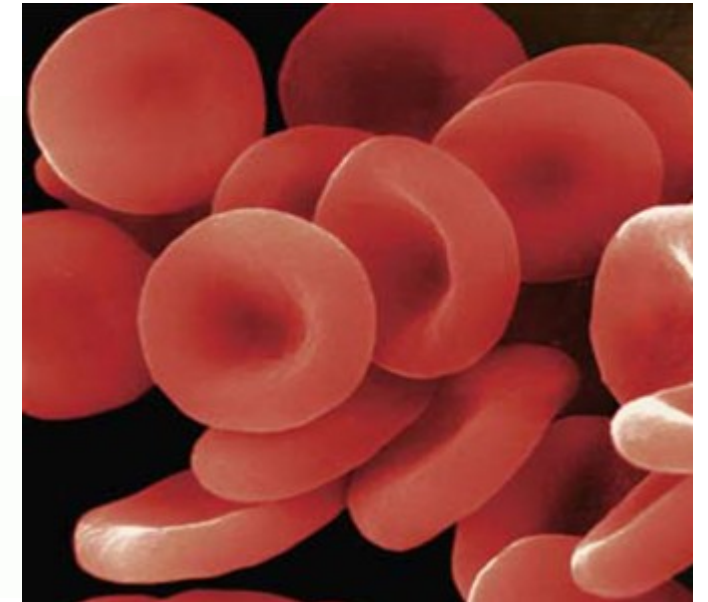
Color

Structure

Function

Life span

**Normal
&
Abnormal**





RBCs

Number (count):

The number of erythrocytes/cubic millimeter of blood.

- Male: 5-5.5 million/mm³
- Female: 4.5-5 million/mm³

why?

Less in females due to:

1. Monthly blood loss with **menstruation**.
2. Inhibitory effect of **female hormones** on the

Abnormal Number

- **Polycythemia** (**+++ 6.5 million in males; 6 millions in females**):

Physiological: High altitude, newborn

Pathological: Chronic heart/ respiratory disease Hypoxia
Renal cell carcinoma Increased

erythropoietin

Relative Polycythemia: increased RBCs count due to decreased plasma volume

ex. Dehydration

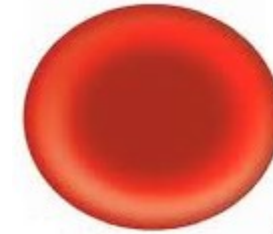
- **Oligocythe** **Decrease in RBCs count &/or ↓ Hb concentration** (**4 millions in F**):

RBCs

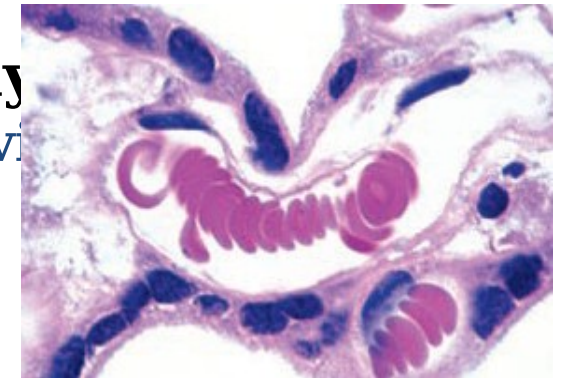


Shape:

- Top view: Rounded
- Side view: **Biconcave** disc



“Rouleau appearance”: stacks of coins
(in: small vessels, multiple myeloid cells)
(in areas with low velocity and high viscosity)



The stability of the biconcave shape is due to

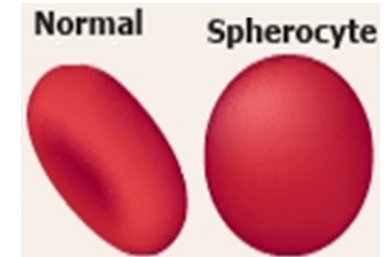
Presence of special peripheral cytoskeleton
formed of

- Provide **actin filaments** bond to **spectrin** and **ankyrin** proteins to increase surface area for gas exchange.
- Places most of Hb in contact with the cell surface to facilitate gas exchange.

Abnormal shape of RBCs

“Poikilocytosis”

- **Spherocytosis:** spherical erythrocytes due to abnormal cytoskeleton.



- Spherocytes can't adapt to changes in their environment (e.g., osmotic pressure and mechanical deformities), which results in premature destruction of the cells and hemolysis

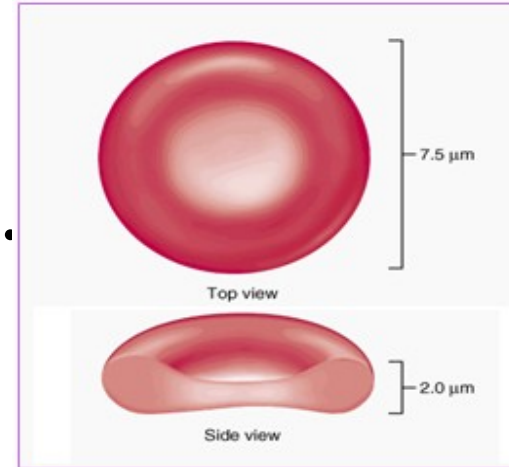
RBCs



Size:

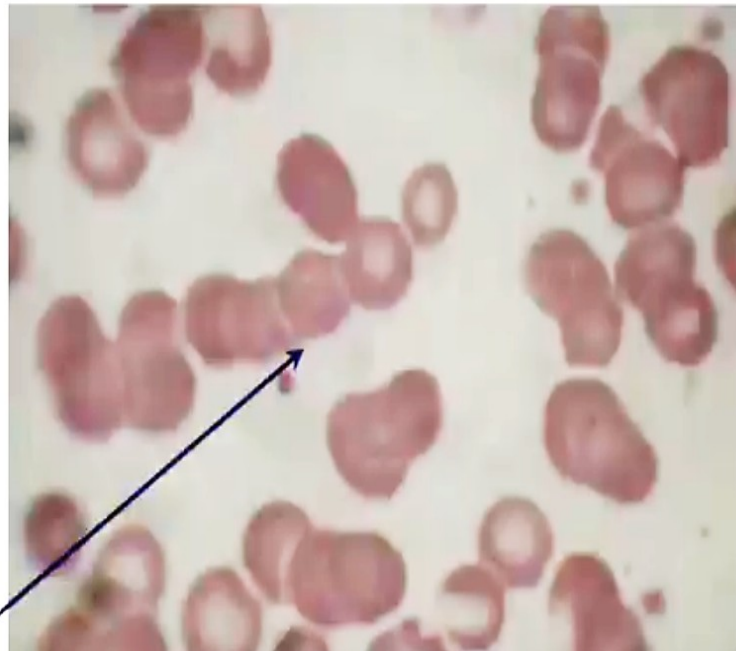
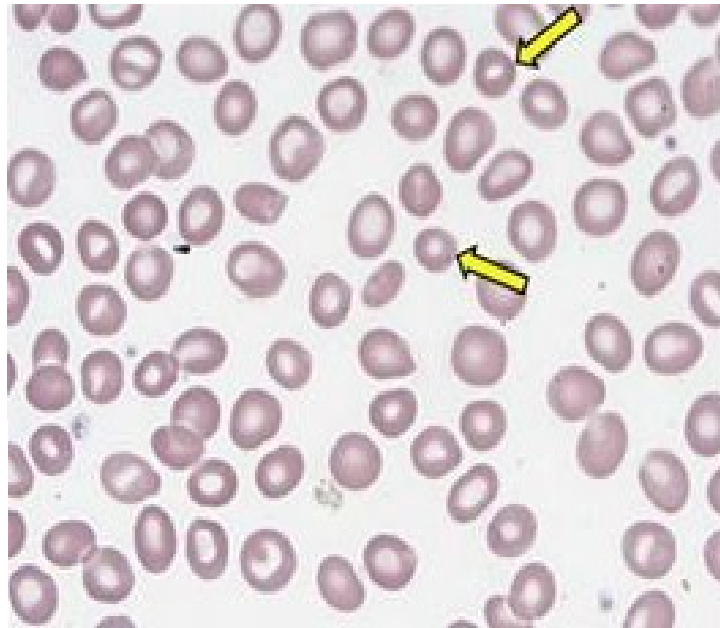
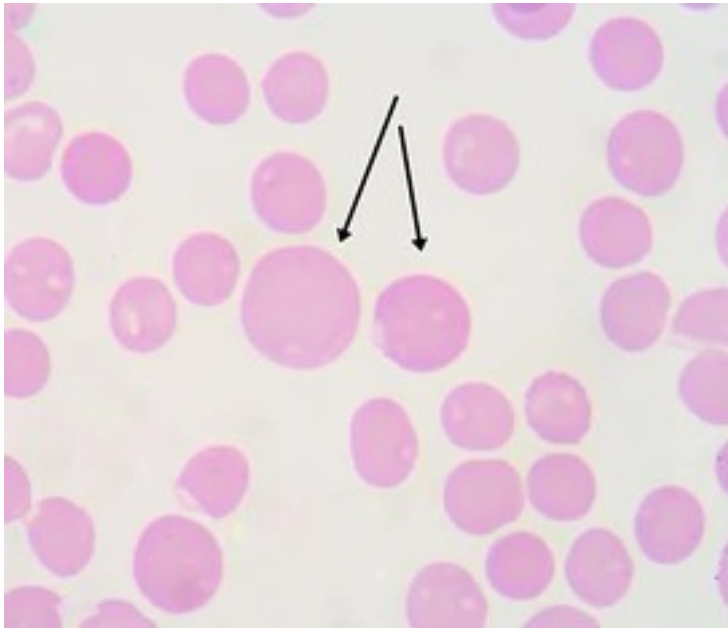
- Diameter: average **7.5 μm** .
- Thickness: about 2.6 μm (periphery) & 0.5 μm (center)

RBCs with normal size =
Normocytes



Abnormal Size

- Diameter $> 9 \mu\text{m}$ = **Macrocyte**
- Diameter $< 6 \mu\text{m}$ = **Microcyte**
- Different sizes = **Anisocytosis**



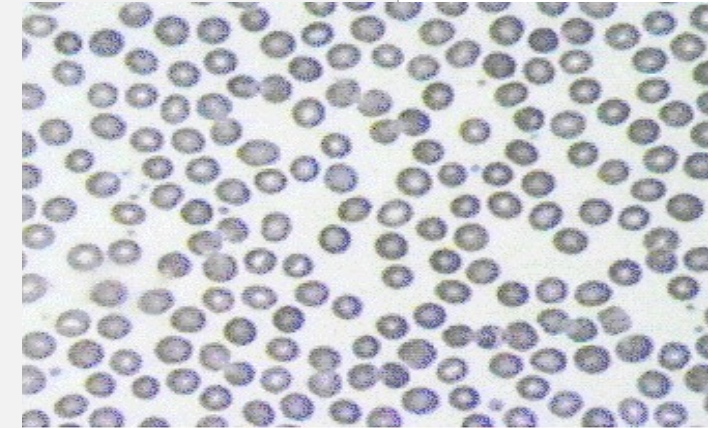
RBCs



Color:

Unstained RBCs:

- Single cell: **greenish yellow** condition.
- Grouped cells: **red** in color (due to their **hemoglobin** pigment content)

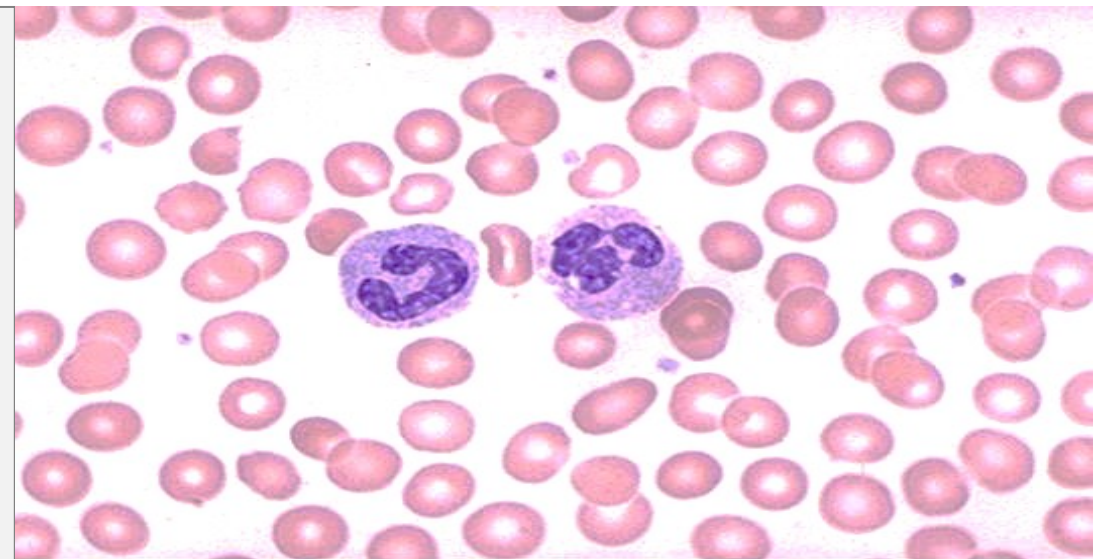


Blood%20Cells%20A%20P
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Stained “Blood film” with

leishamn’s stain:

RBCs appear **acidophilic** (because of Hb is protein) with a **pale central area** (=Normochromic) about 1/3 of its diameter.

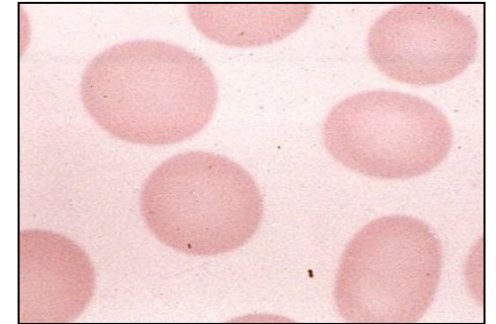


Abnormal Color

Normal Hb: 14-18g/dl in males & 12-16g/dl in females.

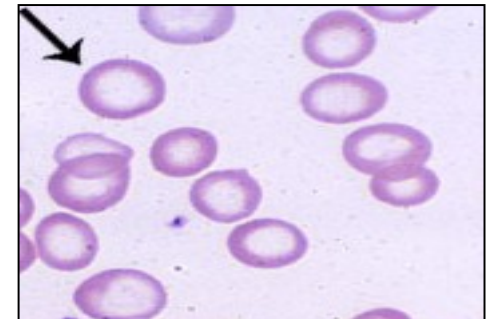
More Hb content than normal

- **Hyperchromic** **stained central area** & a more deeply stained periphery

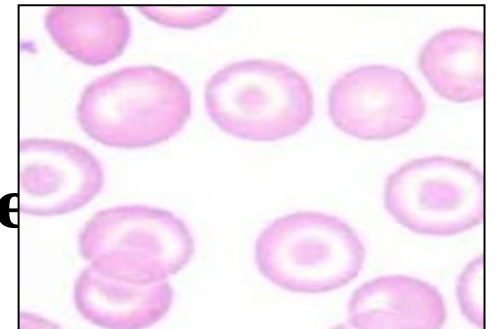


Less Hb content than normal

- **Hypochromic** **Larger pale central area** and pale staining periphery.



- **Target cell** (Hb at the center with pale periphery)
(in Hb abnormality, thalassemia, liver disease)



RBCs



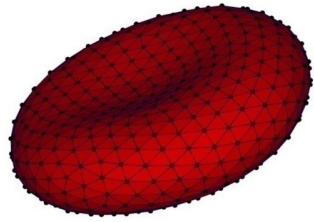
Structure:

- Bag of Hb surrounded by plasma membrane.
- They lack nucleus, mitochondria and organelles giving a space for the Hb inside them.



Hemoglobin is O₂-carrying protein

❖ Molecular structure of the plasma membrane of erythrocyte
it is formed of lipid bilayer that contains 2
groups of proteins



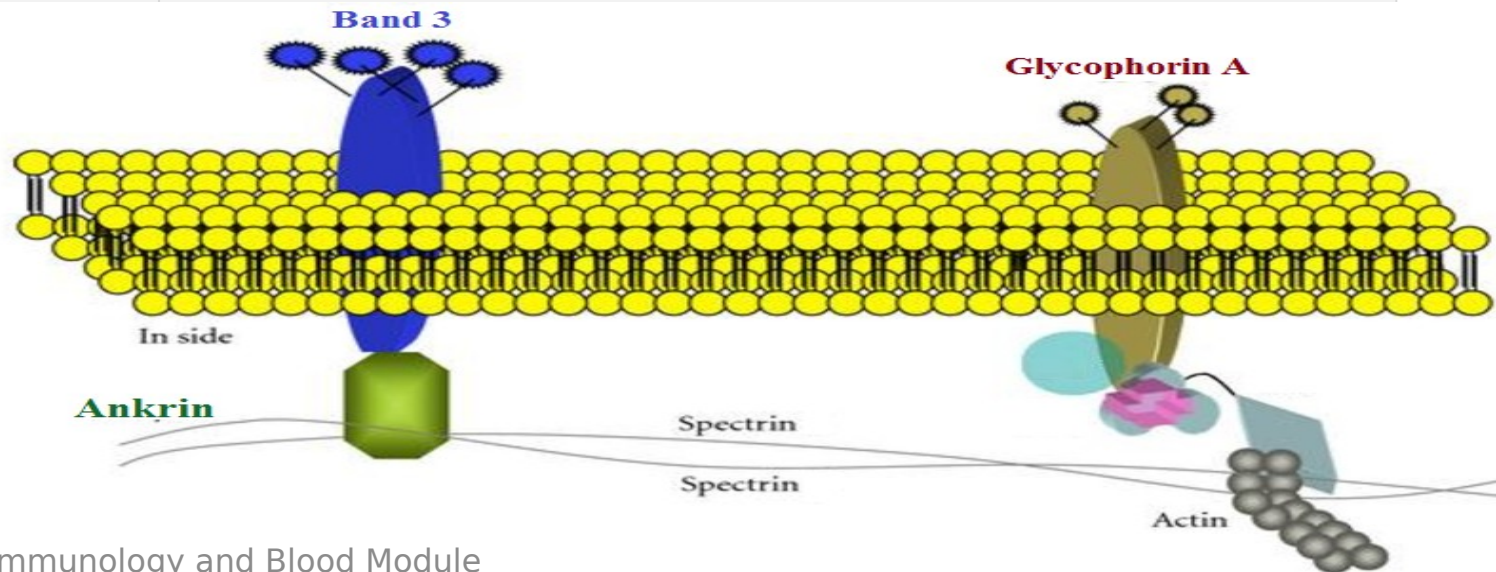
Intrinsic “transmembrane”
proteins

- Ion channels
- Band 3 protein: binds Hb and ankrin

They have extracellular glycosylated parts that form the antigenic sites responsible for **ABO blood typing**

Peripheral proteins (on inner surface):

- Spectrin (form a network that bind to Actin)
- Ankyrin which anchors the



The unique structure of the plasma membrane of the erythrocytes maintains:

- 1- **The biconcave** shape of erythrocytes.
- 2- **The flexibility of RBCs with round edges** that enables them to change their shape inside narrow capillaries then regain their shape in wider vessels.
- 3- **Its selective permeability** to ions and gases.
- 4- **Easy accessibility of Hemoglobin to oxygen.**

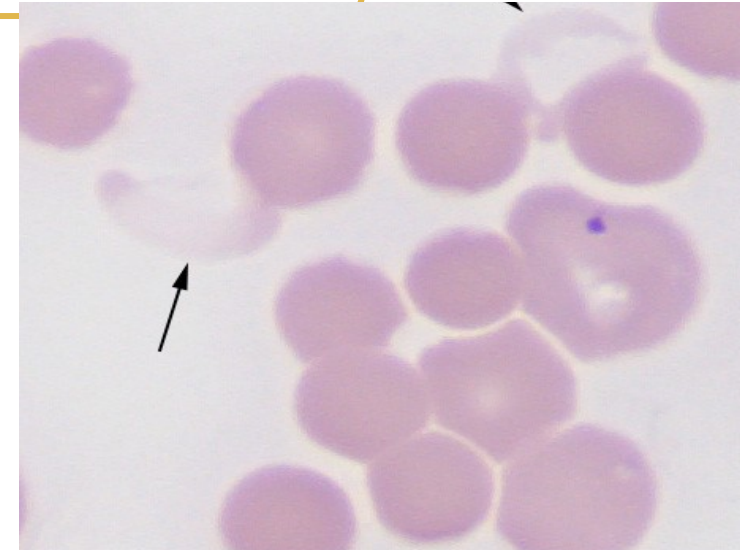


Plasma membrane permeability

If blood is added to hypotonic solution



Hemolysis

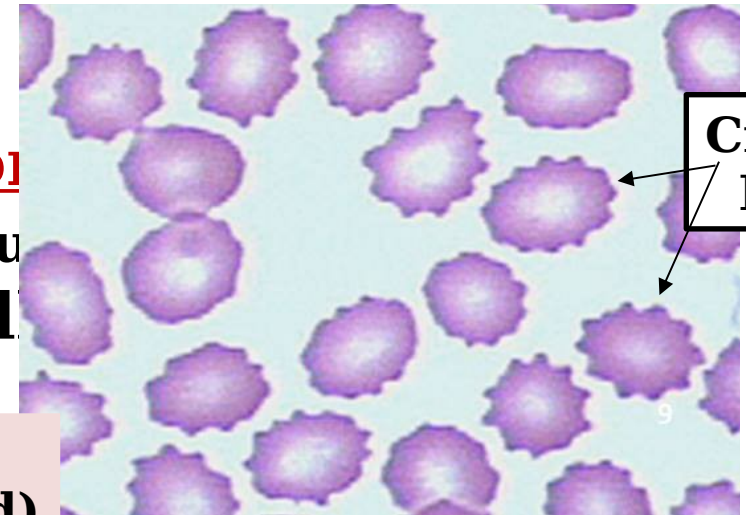


If blood is added to hypertonic solution



“Crenation” = Undulated surface

“Echinocyte = Burr cell”



Crenated RBCs

Artifact or uremia
(high level of nitrogen waste products in the blood)

RBCs

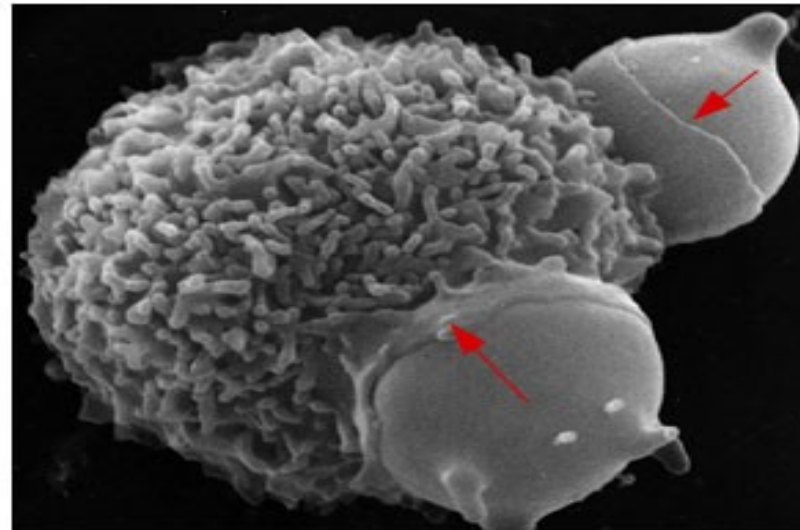


Life span:

- About **120 days**
- Then, they become fragile and fragmented when passing through narrow vessels.
- The fragments are phagocytosed and removed by

macro

and



5 μm



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Adaptation of erythrocytes' **structure** to their **function**

- 1- **Absence of nucleus and organelles** give more space for Hb.
- 2- **The biconcave shape** of erythrocytes:
 - a. Provides a large surface area/volume ratio to increase surface area for gas exchange
 - b. Places most of Hb in contact with the cell surface to facilitate gas exchange
- 3- **The flexibility of RBCs with round edges** enable them to pass through narrow capillaries.
- 4- **Plasma membrane of erythrocytes** prevents the escape of hemoglobin to plasma.

Clinical Correlation

Anemia

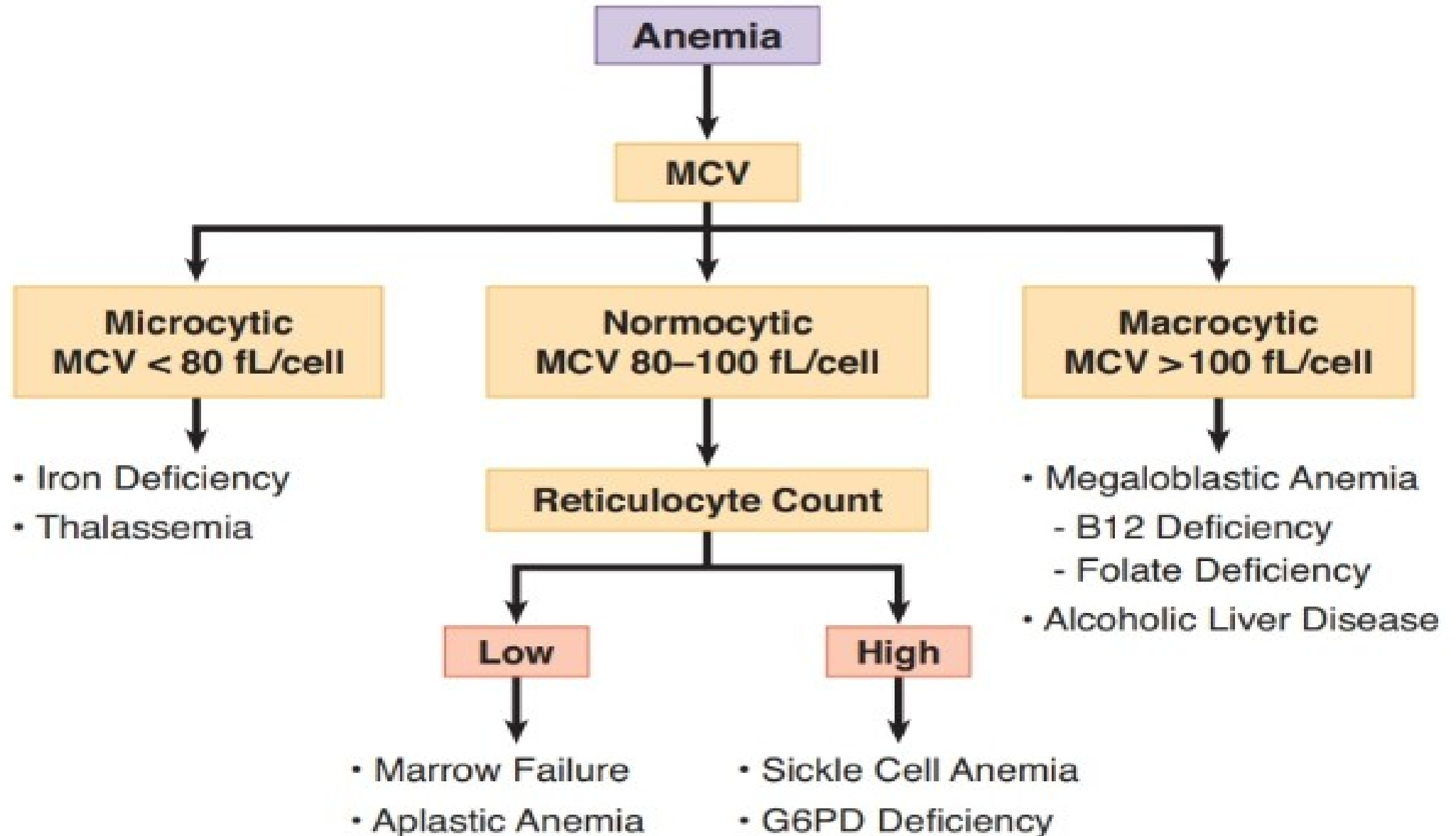


Classification of anemia can be based on

I. Color:

- a. Normochromic A.:** normal color (central pallor = $\frac{1}{3}$ of the diameter).
- b. Hypochromic A.:** decreased color (increased the central pallor).
- c. Hyperchromic A.:** have increased color (loss of central pallor).

II. Mean Corpuscular Volume (MCV):



Anemia

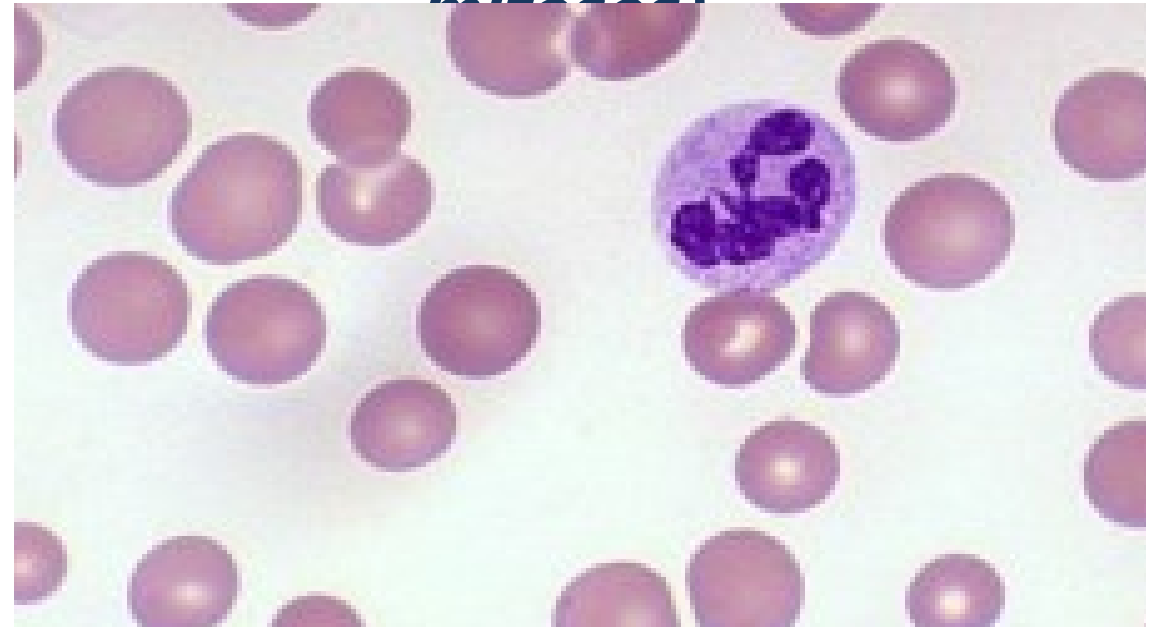


Microcytic hypochromic
ex. Iron deficiency anemia
Thalassemia

Macrocytic /megaloblastic
ex. Deficiency of Vit B12
(Pernicious a.)

Deficiency of folic acid

impaired DNA synthesis (delayed mitosis)



Summary

RBCs (Erythrocytes)



Origin: Stem cells in red bone marrow

Number: about 5 million/mm³ (the most abundant blood component)

Shape: flexible, biconcave disc / “Rouleau” / **spectrin & ankrin.**

Size: about 7.5 μm in diameter / 2 μm & 0.5 μm thickness.

Color: acidophilic with a pale central area (about 1/3).

Structure: transmembrane proteins; **glycophorin A & band 3 protein** form the basis for the ABO blood typing.

Function: contains O₂-carrying protein hemoglobin

Life span: 120 days / removed by macrophage of liver, spleen & BM.

Quiz



Red blood cells are characterized by

- a. Biconcave shape
- b. Small pyknotic nucleus
- c. Having a diameter 12 μm
- d. Inflexible cytoskeleton
- e. Undifferentiating.

In structural adaptation of RBCs, there is

- a. Free ribosomes for protein synthesis.
- b. Mitochondria for energy production.
- c. Rounded shape for easy passage of oxygen.
- d. Biconcave flexible shape to pass through narrow capillaries.
- e. Numerous organelles.

Which component of the erythrocyte cell surface is responsible for determining blood type (the A-B-O system)?

- a. Fatty acid
- b. Carbohydrate
- c. Nucleic acid
- d. Protein
- e. Cholesterol

What is the approximate life span of a circulating erythrocyte?

- a. 8 days
- b. 20 days
- c. 5 weeks
- d. 4 months
- e. 1 year

For a laboratory blood test, fresh blood sample is drawn and centrifuged in the presence of heparin as an anticoagulant to obtain a hematocrit. From top to bottom, the fractions resulting from centrifugation are which of the following?

- a. Serum, packed erythrocytes, and leukocytes
- b. Leukocytes, erythrocytes, and serum proteins
- c. Plasma, buffy coat, and packed erythrocytes
- d. Fibrinogen, platelets, buffy coat, and erythrocytes
- e. Albumin, plasma lipoproteins, and erythrocytes

Quiz



Match the following expressions with their meaning

1-Oligocythemia

2-Poikilocytosis

3- Polycythemia

4- Anisocytosis

a. Increased number of RBCs

b. Variation in size of RBCs

c. Decreased number of RBCs

d. Variation in shapes of RBCs

Quiz



Reasons:

RBCs are biconcave?

a. Provides a large surface area/volume ratio to increase surface area for gas exchange.

ABO types of RBCs?

b. Places most of Hb in contact with the cell surface to facilitate gas exchange.

They have transmembrane proteins, glycophorin A & band 3 protein, that display extracellular glycosylated parts that form the antigenic sites responsible for ABO blood typing.

Mechanical stability and flexibility of RBCs?

Presence of special peripheral cytoskeleton formed of actin filaments bond to spectrin and ankyrin proteins.

Suggested textbooks



- 1. Junqueira`s Basic Histology; Text and Atlas. 14th edition 2016.**
- 2. Histology atlas and test: Michael H. Ross and Wojciech Pawlina, 7th edition, 2015.**



Thank
you

